5.0 STORM WATER MANAGEMENT CONTROLS

This section of the SWPPP describes storm water management measures to control and abate water quality impairment associated with the activities described in the preceding sections.

Land conversion associated with development has resulted in the loss of vegetation and sensitive wetlands, alteration of natural drainage patterns, and the creation of expanded areas of imperviousness. This loss of infiltration capacity has correlated with increases in the velocity, volume, and frequency of storm water runoff. Mitigation of this process is inherently complex in that sources are somewhat diverse, changes in water quality tend to be gradual and cumulative, and the site-specific physical and safety constraints associated with the configuration of the different facilities tend to limit the number of viable measures for implementation at each site. However, since pollutants have a limited number of pathways by which they reach water resources, the practices that constitute management measures for the various source categories tend to be somewhat similar for each construction activity.

The design and implementation of effective source control measures is achieved from a management systems approach as opposed to an approach that focuses on individual practices. That is, the pollutant control achievable from any given management system is viewed as the sum of the parts, taking into account the range of effectiveness associated with each single practice, the costs of each practice, and the resulting overall cost and effectiveness of the system. Some individual practices may not be effective alone but, in combination with others, may provide a key function in a highly effective system. This is analogous to the use of "treatment trains" or a series of treatment steps.

This guidance adopts the approach of specifying management measures as systems of management practices. This approach is primarily reflected in two ways: (1) the management measures are usually presented as systems, and (2) for those sources that generate pollutants from a number of discrete activities, or unit areas, the guidance includes management measures for each activity, or area.

It is generally not possible to prescribe a highly specific management measure that will be uniformly applicable over an expanded region. For example, when designing erosion and sediment control systems, one considers soil types, antecedent moisture conditions, land use, precipitation patterns, and slopes to determine the proper set of practices. The multitude of combinations of site-specific factors that arise within a state, region, and even within a watershed, makes it difficult to develop a list of specific management measures to be used.

Congress has defined management measures as "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operation methods, or other alternatives." Congress has not defined the term "economically achievable," nor has it explained the term in legislative history. This distinction relates to the extensive flexibility inherent in implementing pollution prevention management measures. The ability of a particular management measure to deal with nonpoint source pollution from a particular site is subject to a variety of factors (e.g., geography, geology, soils, hydrology, and production methods) too complex to address in a single set of simple, mechanical prescriptions at the state or regional level, so this guidance provides considerable flexibility for local selection. These considerations make it difficult to predict the costs and economic impacts of measures that will ultimately be developed, applied, and implemented on a localized basis. Many of the proposed management measures are regarded as low-cost, yet highly effective. Examples include source control measures such as spill prevention or pesticide management. Others are more expensive, yet widely practiced (e.g., construction management measures such as erosion and sediment control practices, storm water management measures such as constructed wetlands or pond systems). This guidance provides a set of management practices for each source category. The number and type of systems identified per source category are based upon the range and diversity of substantively different subcategories and pollutants. Pollution prevention is generally considered as the first component of management measures. Pollutant delivery reduction measures are typically added only after it is determined that additional control is necessary to reach the greatest degree of pollutant reduction economically achievable.

For each management measure, a list of management practices that can be used in designing an equivalent or better system is provided. The list of practices reflects the best available set of practices, or components of best available systems, but is not all-inclusive of those practices that could be used to develop systems that are equivalent to or better than specified management measures.

The pollutant reduction estimates that can be achieved using the specified management practices are also described in this guidance, quantitatively wherever possible. These reductions serve as the benchmarks for equivalent or better management measures. All estimates provided are based upon the best available data currently available, but are somewhat empirical. Further monitoring will provide data to support the effectiveness of this portion of the SWPPP.

The controls to be implemented at each construction activity will reflect the identified potential sources of pollutants at each construction site. This list of sources will be different for each construction activity. It is recommended that the SWPPP personnel or committee be responsible for implementing the appropriate control measures for the construction activity. Each construction activity will find some solutions more appropriate or feasible than others.

5.1 The Nonpoint Source Pollution Process

Nonpoint source pollutants are transported to surface water by a variety of means, including runoff and ground water infiltration. Ground water and surface water are both considered part of the same hydrologic cycle when designing management measures. Ground water contributions of pollutant loadings on surface waters are often very significant. The transport of nonpoint source pollutants to surface waters through ground water discharge is governed by physical and chemical properties of the water, pollutant, soil, and aquifer.

The combination of source control and delivery reduction measures and the application of those measures as components of management systems are dependent upon site-specific conditions. Technical factors that may affect the suitability of management measures include, but are not limited to, land use, climate, size of drainage area, soil permeability, slopes, depth to water table, space requirements, the type and condition of the receiving waters, depth to bedrock, and the pollutants to be addressed.

5.2 Source Control Measures

Source control is the first opportunity in any nonpoint source control effort. Source control methods vary for different types of nonpoint source problems. Examples of source control include:

(1) Reducing or eliminating the introduction of pollutants to a land area.

(2) Preventing nonintroduced pollutants (such as loose dirt and sediments) from leaving the site during land-disturbing activities.

(3) Preventing interaction between precipitation and introduced pollutants.

(4) Protecting wetlands or riparian habitat and other sensitive areas.

(5) Protecting natural hydrology.

5.2.1 Preventive Maintenance (PM)

A Preventive Maintenance (PM) program is an effective and cost-efficient measure in pollution prevention. It is easily performed at a relatively low cost and may yield great savings in the long run. Preventive maintenance includes inspection of construction activity/contractor equipment and systems, such as equipment cleaning facilities, all vehicular and maintenance facilities, and any structural source controls already in place, such as drip pads, sumps, and tank containment. Each contractor should be directly responsible for inspection, testing, adjustment, and repair of their contractor-owned facilities and equipment, subject to the supervision and review by the SWPPP committee. Contractor-owned facilities, equipment, and maintenance records will be reviewed by construction activity SWPPP personnel on a regular scheduled basis.

5.2.2 Requirements in PM Program

The preventive maintenance program should include the following:

- Identification of the equipment and systems to which the preventive maintenance program should apply.
- Periodic inspections of identified equipment and systems.
- Periodic testing of equipment and systems.
- Appropriate adjustments, repair, or replacement of parts.
- Maintenance of all records of inspections and follow-up actions.

Preventive maintenance inspections should be carried out by trained personnel or the designated SWPPP committee. It is important that the personnel be familiar with the systems and equipment to be monitored and tested. The inspection schedules should be established by the committee, in conjunction with the construction activity manager, and brought to the attention of all employees. Inspection frequencies can be established in part by reviewing any "Risk Identification and Assessment" studies that may have been completed for the construction activity, equipment, facilities, or contractor activity. In some cases, monthly inspections will be appropriate. A testing schedule can be developed in the same manner; however, testing frequencies will not need to be as often as inspection frequencies. Adjustments or repairs of any type to the equipment or systems must be completed by trained personnel.

Documentation and retention of records is a critical element of a good preventative maintenance and inspection program. A tracking or follow-up procedure will be used to ensure that the appropriate response to the inspection findings has been made. All inspection documentation and records must be maintained with the SWPPP documentation for a period of 3 years following final stabilization. The tables and exhibits located in Appendix D should be used to record inspection and maintenance activities and any corrective actions implemented.

Inspection and maintenance guidelines for construction equipment should follow the manufacturer's specifications. The equipment itself should be serviced in designated areas as indicated above. Special attention must be given to those portions of the equipment that come into contact with any suspected pollutant. These portions include, among others: trams or conveyor mechanisms, pipes for liquid conveyance (including vacuum hoses for liquid extraction), tanks and associated valves, fittings, nozzles, and tank seams. Particular attention should be given to remedying leaks and replacement of deteriorated rubber or plastic hoses, pipes, washers, and gaskets.

Good housekeeping refers to the cleaning and maintenance practices conducted at the construction activity. Good housekeeping is an important component of the pollution prevention plan. Periodic training of employees in housekeeping techniques for those areas of the construction activity where pollutant sources are found reduces the significant material contamination of storm water. Housekeeping practices include:

- Maintenance of material loading/unloading areas.
- Safe and orderly storage of construction debris, chemicals, and other significant materials.
- Stimulating employee interest in good housekeeping.

Maintenance areas should be kept clean. Chemicals, grease, oil, solvent, and fuel spills should be collected by use of absorbents and booms where necessary. Disposal of these materials should be by qualified hazardous materials handling contractors. Material loading and unloading areas should be cleaned manually or with heavy equipment. Liquids should be removed using absorbent materials or with vacuum machinery.

Cleaning protocols should be site-specific. The protocols should fit the nature of construction activity (and tenant organizations). The protocols should be developed to meet the site-specific requirements of the construction activity. The protocols should cover:

- Areas, operations, and equipment to be inspected.
- Frequency of inspection.
- Checklists and procedures to be used.
- Records of inspection and filing requirements.
- Records of resulting maintenance and filing requirements.
- Mechanism for revising protocols.

5.3 Delivery Reduction Measures

Pollution prevention often involves delivery reduction (intercepting pollutants prior to delivery to the receiving waters) in addition to appropriate source control measures. Management measures include delivery reduction practices to achieve the greatest degree of pollutant reduction economically achievable, as required by NPDES regulations.

Delivery reduction practices intercept pollutants leaving the source by capturing the runoff or infiltrate, followed either by treating and releasing the effluent or by permanently keeping the effluent from reaching a surface or ground water resource. By their nature, delivery reduction practices often bring with them side effects that must be accounted for. For example, management practices that intercept pollutants leaving the source may reduce runoff, but also increase infiltration to ground water. These devices, although highly successful at controlling suspended solids, may not, because of their infiltration properties, be suitable for use in areas with high ground water tables and nitrate or petroleum residue problems. The performance of delivery reduction practices is to a large extent dependent on suitable designs, operational conditions, and proper maintenance. For example, filter strips may be effective for controlling particulate and soluble pollutants where sedimentation is not excessive, but may be overwhelmed by high sediment input. In many cases, filter strips are used as pretreatment or supplemental treatment for other practices within a management system.

5.3.1 Storm Water Management BMP's

The evolution of the need to manage or control storm water runoff has directly paralleled the evolution of land development and its impact on the environment. In the past, control of storm water was attempted by maximizing conveyance with rapid downstream disposal of surface water. The cumulative effects of this practice have created frequent downstream flooding and depletion of underground water supplies. Until the early 1970's little or no consideration was given to the downstream impacts of such activity. Current practices dictate the attenuation of design peak flows to predevelopment rates. While this approach has proven reasonably effective in curtailing flooding problems, it does not mitigate the adverse impacts of pollutant export. The first flush of pollutants refers to the higher concentrations of storm water pollutants that characteristically occur during the early part of a storm with concentrations decaying as the runoff continues. Concentration peaks and decay functions vary from site to site and from region to region, depending on contributing land use, the pollutants of interest, and the characteristics of the drainage basin. Studies have indicated that for a variety of land uses the first 1.25 cm (0.5 in.) of each runoff contains 80 to 95 percent of the total annual loading of most storm water pollutants. The best available procedures for storm water management include both structural and nonstructural components and involve a combination of detention, infiltration, and filtering devices. Treatment systems, rather than individual practices, will tend to achieve the greatest pollutant reduction goal. Treatment systems should include source control, storm water management, and riparian protection to achieve the highest level of effectiveness.

Storm water treatment systems are site-specific and their effectiveness is highly variable and dependent on many factors. Practices or combinations of practices that are considered to be "best available" in some or in many situations, nevertheless, may not be the most effective or economically achievable for a particular site, and may even be entirely ineffective for the site. A system of practices should be tailored to a particular site to avoid selection of unsuitable practices, maintenance problems, or failure to achieve desired pollutant reduction.

Storm water management controls are constructed to prevent or control pollution of storm water after the construction is completed. The general permit requires that the pollution prevention plan include a description of the measures that will be installed to control pollutants in storm water after construction is complete. For sites in which the development results in runoff flows that are higher than preconstruction levels, the SWPPP must include a technical explanation of why a particular storm water management measure was selected.

Selection of the most appropriate BMP depends upon a number of factors associated with site conditions. EPA expects that most sites can employ measures to remove 80 percent of the total suspended solids from postconstruction runoff. When selecting BMP's for a development project, consider the impacts of these measures on other environmental media (e.g., land, air, and ground water).

In addition to pollutant removal, the SWPPP must address velocity dissipation at discharge locations. Development usually means an increase in speed with which the site will drain because of the addition of paved areas, storm sewers, curbs, gutters, etc. The general permit requires that the velocity dissipation devices be placed along the length of any outfall where the discharge from the developed area may erode the channel. See Section 3.3 for further information on runoff calculations.

5.3.2 Storm Water Retrofit

Retrofit projects must take into account a number of site-specific factors. Nature of pollutants, loading rates, classification of receiving waters, location and condition of existing storm drains, existing and proposed land uses, location of existing utilities, soil characteristics, and floodplain location are but a few. A brief discussion of these practices follows:

Pond Systems

The ponds described in the following paragraphs range from completely dry structures to permanently wet structures with various combinations included. In addition, wetland components are discussed for their ability to enhance pollutant removal, create habitat diversity, and provide visual interest.

<u>Wet Extended Detention Pond</u> - A permanent pool system containing a forebay near the inlet to trap sediments and a deeper pool near the riser. This pond system provides an optimal combination of downstream channel protection and pollutant removal. Extended detention wet ponds are generally the most cost-effective urban/coastal practices available for pollutant removal and storm water control.

<u>Wet Pond</u> - A pond system with all of its storage utilized as a permanent pool. This system traps sediments and may provide pollutant removal through biological uptake from aquatic wetland plant species. In addition, a wet pond can be an attractive aesthetic feature.

<u>Extended Detention (ED) Micro-Pool</u> - A dry ED system containing one or two small permanent pools for pollutant removal. One micro-pool located near the inlet acts as a sediment forebay. The micro-pool system has a much lower maintenance burden than conventional dry ED pond systems and is a particularly useful design for fingerprinting a pond into a sensitive woodland or wetland area.

Extended Detention Shallow Marsh - A system utilizing emergent aquatic wetland plant species as its principal pollutant removal mechanism. The ED shallow marsh typically consists of a 0- to 1-meter- (0-3 feet) deep irregularly shaped permanent pool, creating diverse wetland habitats in a relatively small space, while providing moderate levels of soluble pollutant removal.

Shallow Marsh - A system with much of its storage devoted to a shallow marsh, this pond design can consume a great deal of land area. However, with proper grading, design, and propagation techniques, this system can result in the creation of an extensive, high quality emergent wetland habitat. The shallow marsh can achieve high removal rates of soluble and particulate pollutants through the biological uptake mechanism of emergent aquatic plants.

In-Filter Dry Pond - An innovative dry pond system for sites having permeable soils that promote infiltration. Design includes storm water detention, pretreatment via plunge pools and grassed swales, and a series of infiltration trenches and basins.

Dry Extended Detention Pond - A pond system typically comprised of two stages: The upper stage is graded to remain dry except for infrequent storms; whereas the lower stage is designed for regular inundation. Runoff pretreatment is difficult to achieve with this pond system, and it is equally difficult to prevent clogging of the ED control device.

Wet Ponds and Wet Extended Detention Ponds are extremely effective water quality practices. When properly sized and maintained, Wet Ponds and Wet Extended Detention Ponds can achieve high removal rates for sediment, biochemical oxygen demand (BOD), nutrients, and trace metals. Biological processes within the pond also remove the soluble nutrients (nitrate and ortho-phosphorus) that contribute to nutrient enrichment (eutrophication). Soluble nutrient removal is achieved through a process known as biological uptake where algae and other aquatic plants convert the soluble nutrients into biomass which eventually settles into pond sediments and is later consumed by bacteria. Some of the nutrients are recycled to the water column, but most nutrients remain in the consolidated sediments.

Wet Extended Detention Ponds are most cost effective in larger, more intensely developed sites. Pond practices normally require a significant contributing watershed area (greater than 4 hectares or 10 acres) to ensure proper operation. Positive impacts associated with wet pond systems can include: creation of local wildlife habitat, increased property values, recreation, and landscape amenities.

Extended Detention Ponds are effective in controlling postdevelopment peak storm water discharge rates to a desired predevelopment level for the design storm(s) specified. If storm water is detained for 24 hours or more, as much as 90-percent removal of particulates or suspended solid pollutants is possible. It should be noted, however, that extended detention ponds have the disadvantage of elevating water temperatures, thus potentially contributing to thermal pollution. Their use may be inappropriate in some locations, such as, adjacent to trout streams. In addition, care should be taken not to reduce base flows below those necessary to sustain the resident aquatic habitat.

Infiltration Systems

The infiltration systems described below range in design from stone-filled trenches and basins to permeable asphalt pavement. All utilize differing methods for removing soluble and fine particulate pollutants found in storm water runoff. To prevent infiltration systems from becoming clogged with fine sediment, it is essential to pretreat the incoming runoff. Methods of pretreatment range from filter cloth to vegetated filter strips. With pretreatment, infiltration systems can be an effective component of a water quality management measure.

It is important to recognize that infiltration systems create a risk of transferring pollutants from surface water to ground water. Therefore, infiltration systems should not be used near wells, in wellhead protection areas, in areas with high ground water, or in karstic terrain or in settings in which drinking water supplies may become contaminated. Furthermore, concentrations of toxic materials leached into the substrate could result in a hazardous waste designation for the area subject to regulations under CERCLA.

Infiltration Trench #1 - An infiltration trench works by diverting storm water into a shallow (1 to 2.5 meter or 3 to 8 feet) excavated trench which has been backfilled with stone to form an underground reservoir. Runoff is then either exfiltrated into the substrate or collected in underdrain pipes and conveyed to an outfall. Infiltration trenches are an adaptable practice that adequately removes both soluble and particulate pollutants. They are primarily an onsite control and are seldom practical or economical for drainage areas larger than 2 to 4 hectares (5 to 10 acres). Infiltration trenches are one of the few practices that adequately provide pollutant removal on small sites of infill development. They preserve the natural ground water recharge capabilities of a site and can often fit into margins, perimeters, and other unused areas of the site. A disadvantage is that infiltration trenches require careful construction, pretreatment, and regular maintenance to prevent premature clogging. Infiltration trenches can be used effectively in sandy or sandy loam soil areas but are much less effective for clayey or silty soils.

Infiltration Trench #2 - Similar to the trench system described above, this design accepts sheet flow from the lower end of a parking lot or paved surface. Runoff is diverted off the paved parking lot through slotted curbs. The slotted curbs function as a level spreader for storm water. A grass filter strip separates the trench from the paved surface for capture of sediments. This trench includes a perforated PVC-type pipe for passage of large design storm events. At the end of the trench is a grassed berm to ensure that runoff does not escape.

Infiltration Basin - Infiltration basins are an effective means for removal of soluble and fine particulate pollutants. Unlike other infiltration systems, basins are easily adaptable to provide full control for peak storm events. Basins can also serve large drainage areas (up to 20 hectares or 50 acres). Basins are a feasible option where soils are permeable. Basins are advantageous in that they can preserve the natural water table of a site, serve larger developed areas, be used as a construction sediment basin during construction and converted later to a long-term BMP, and are reasonably cost-effective in comparison to other practices.

One disadvantage is the need for frequent maintenance. In addition, infiltration basins have sometimes failed because they were installed in unsuitable locations or soils.

Dry Well - A small infiltration system designed to accept storm water from a roof-drain downspout. Rather than dispersing its storm water across a paved surface or grassed area, the downspout pipe connects directly into the dry well which filters rooftop runoff into soils. This system should not be used near foundations where expansive soils are found, as foundations may be damaged.

Porous Pavement - Porous pavement is a permeable pavement having the capability to remove both soluble and fine particulate pollutants in runoff and provide ground water recharge. Use is generally restricted to low-traffic-volume parking areas. Porous pavement systems can receive runoff from adjacent rooftops. This reasonably cost-effective practice is only feasible on sites with gentle slopes, permeable soils, deep water tables, and bedrock levels. It also requires careful design, installation, and maintenance. Although porous pavement has the high capability to remove both soluble and fine particulate pollutants from storm water runoff, it can become clogged easily and is difficult and costly to rehabilitate.

From a pollutant removal standpoint, Infiltration Trenches, Basins, and Porous Pavement have a moderate to high removal capability for both particulate and soluble pollutants, depending upon how much of the annual runoff volume is effectively exfiltrated through the soil layer. It should be noted that infiltration practices should *not* be entirely relied upon to achieve high levels of particulate pollutant removal (particularly sediments), because these particles can rapidly clog the device. For these systems to be effective, particulate pollutants must be removed before they enter the structure by means of a filter strip, sediment trap, or other pretreatment devices, and these devices must be regularly maintained.

Filter Strips

The filter systems described below rely on various forms of erosion-resistant vegetation to amplify particulate pollutant removal, improve terrestrial habitat, and enhance the appearance of a site. In addition, filter systems can improve both the performance and amenity value of pond and infiltration practices via storm water pretreatment.

Grass Filter Strip - These are similar to a grassed swale, but they can only accept overland flow. Filter strips are effective when used to protect surface infiltration trenches from clogging by sediment. They are effective in removal of sediment, organic material, and trace metals. They should be used as a component in an integrated storm water management system. Filter strips are inexpensive to establish if preserved prior to site development. As with all filter systems, long-term maintenance (mowing, inspection for short circuiting, etc.), should be included in overall costs.

Riparian Buffer Strip - Riparian buffer strips improve water quality by removing nutrients, sediment and suspended solids, and pesticides and other toxins from surface runoff as well as from subsurface and ground water flows. The pollutant removal mechanism associated with riparian vegetation combines the physical process of filtering and the biological processes of nutrient uptake and denitrification.

Grassed Swale - This is a grassed, low gradient conveyance channel that provides some water quality improvements for storm water via natural filtration, settling, and nutrient uptake of the grass cover. Often used as an alternative to curb-and-gutter drainage conveyance, grassed swales affect peak discharges by lengthening the time of concentration. They can also be fitted with low check dams to increase removal efficiency via temporary ponding.

Sand Filters - Sand filters are a water quality control filtration system used to remove large particulates from runoff and protect filter media from excessive sediment loading at storm water quality control basins. Sand filters can be used independently or with a dry pond basin element.

Peat/Sand Filters - This is a man-made soil filter system utilizing the natural absorptive features of peat. The system features a grass cover crop and alternating sublayers of peat, sand, and a perforated pipe underdrain system. Systems are presently used for municipal waste effluent treatment and are being adapted for use in storm water management.

Filter strips have a low-to-moderate capability of removing pollutants in urban runoff and exhibit higher removal rates for particulates rather than soluble pollutants. Pollutant removal techniques include filtering through vegetation and soil, settling and deposition, and uptake by vegetation. Riparian buffer strips appear to have a higher pollutant removal capability than grass filter strips. However, length, slope, and soil permeability are critical factors that influence the effectiveness of any strip. Another practical design problem is prevention of storm water from concentrating and thereby "short-circuiting" the strip.

Filter systems are an essential component of a comprehensive nonpoint source control strategy but should generally be used in conjunction with infiltration systems and pond systems as a pretreatment for runoff.

Oil/Water Separators

There are several types of oil-water separators. The basic separators that could be utilized at a construction activity are listed as follows:

SC Separator - An SC separator consists of an underground vault or manhole with an inlet pipe and "T" outlet. The structure of the separator allows for separation of floating oil only and has a capacity for small spills.

API Separator - The API separator consists of a rectangular vault with a series of baffles. Some systems have sophisticated equipment for skimming and removal of oil and other materials.

CPI Separator - The CPI separator consists of a vault that contains a series of closely aligned parallel plates made of fiberglass. The plates are positioned at an angle to the direction of inflow from 0 to 60 degrees.

Oil/water separators may be used within a storm drainage system or as a pretreatment for discharge into the sanitary system or hold tank for removal. An SC separator is effective for retaining small fuel or oil spills. The API and CPI separators are effective in removing diluted oil droplets from storm water. Maintenance must be performed regularly. Oil/water separators must be cleaned frequently to keep accumulated oil from escaping during larger storm events.